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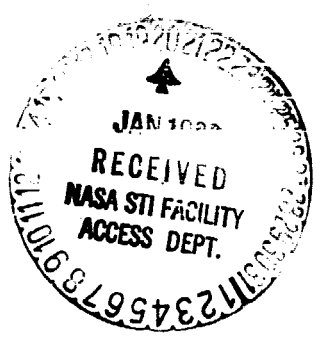

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16. Abstract Specimens of four cast NiAl alloys, three of them containing 0.5, 1.0 and 1.5 at. % Mo., were homogenized for 10, 10, and 140 hr at 1373, 1523 and 1273°K, respectively, then kept at 1073, 1173 and 1323°K for 60, 120 and 3 hr, respectively, and quenched in icy water. The precipitation of a metastable Ni_3Mo phase was observed at temperatures between 1073 and 1523°K. Molybdenum substituted for nickel was found to inhibit the lattice disordering in NiAl at 1073 and 1523 K.

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In spite of considerable interest of scientists [1, 2] in studying the NiAl compounds, its properties have not been adequately studied; in particular, questions as to disordering of NiAl remain open. /142*

In the present work the problem of studying the effect of small additions of molybdenum on the process of disordering of NiAl is presented. Molybdenum in a quantity of 0.5, 1 and 1.5 at. % was introduced into the NiAl alloys by substitution of an equivalent quantity of nickel; according to the constitution diagram of NiAl-Mo, the alloys studied lie in the field of a β-solid solution [3].

Alloys for the study (Table) were prepared from electrolytic nickel, aluminum (99.99%) and molybdenum from an electron-beam melt. The alloying was done in an induction furnace with low pressure argon.

a Сплав	b Содержание в сплаве, ат. %			c Период решетки, Å, после термических обработок		
	Ni	Al	Mo	d отжиг	e закалка с 1273 K	f закалка с 1523°K
$Ni_{1.00}Al_{1.00}$	50.0	50	—	2.8811	2.8811	2.8798
$Ni_{0.99}Mo_{0.01}Al_{1.00}$	49.5	50	0.5	2.8828	2.8734	2.8798
$Ni_{0.98}Mo_{0.02}Al_{1.00}$	49.0	50	1.0	–	2.8750	2.8834
$Ni_{0.97}Mo_{0.01}Al_{1.00}$	48.5	50	1.5	2.8852	2.8778	2.8862

Key:
a. alloy
b. content in the alloy, at. %
c. period of the lattice, Å, after thermal treatment
d. annealing
e. hardening from 1273°K
f. hardening from 1523°K

The cast alloys were subjected to homogenization annealing at 1373, 1323 and 1273°K (holding at each temperature for 10, 10 and 140 hours, respectively). Hardening of the alloys was done in ice water after additional holding at 1073, 1173 and 1323°K for a period of

*Numbers in the margin indicate pagination in the foreign text.

60, 120 and 3 hours, respectively.

A study was made using a method of heat capacity, X-ray phase and microstructure analyses. The initial heat capacity (C_p) in the interval 293--923°K was measured by a method of continuous heating [4]. Error in reproducibility in determining C_p amounted to 0.1% at 95% verified probability. The X-ray analysis was done on diffractograms obtained on the DRON-1 unit for copper CuK_α-radiation. For a precise determination of the periods of the lattice of line 310 it was recorded at a rate of 0.5 degree/min; the calibration standard was a nickel sample. Precision in determining the period of the lattice amounted to $5 \cdot 10^{-4}$ Å.

According to the data of microstructural analysis, the alloys alloyed with aluminum in an annealed state have a structure of a /143
single-phase solid solution; the periods of the lattice of these alloys are larger than the periods of the lattice of NiAl. Obviously, the atoms of molybdenum introduced into the NiAl lattice occupy the Ni positions causing an increase in its period.

The change in heat capacity depending on temperature for the alloys hardened at 1273°K is indicated in Figure 1. For all of the sample the presence of a considerable endothermal effect is characteristic and the maximum effect is fixed for the alloy with 0.5% Mo. Inasmuch as, with repeated heating, the effect observed was not reproduced, one can assume that it involves the formation in the hardened alloys of a metastable phase which is dissolved during heating.

Study of the microstructure of hardened alloys indicates that at a given temperature in the samples a second phase is generated. The lattice period of the alloys is decreased in comparison with the annealed state and on the diffractograms additional lines appear (from α=2.19, 2.04. 1.39, 1.37, 1.32) whose intensity is larger the larger is the content of molybdenum in the alloy. Earlier [5] when studying the kinetics of isothermal transformations in alloys of the Ni-Mo system, a metastable phase of Ni_3Mo was detected. Comparing the

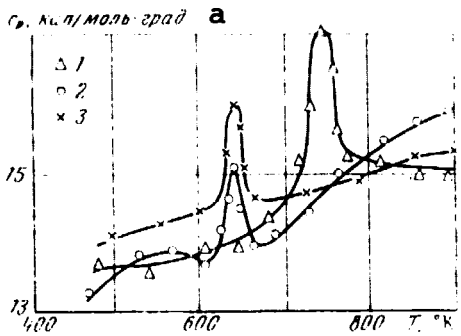

Figure 1. Heat capacities of Ni-Al alloys alloyed with molybdenum after hardening from 1273°K:
1--$Ni_{0.99}Mo_{0.01}Al_{1.00}$,
2--$Ni_{0.98}Mo_{0.02}Al_{1.00}$,
3--$Ni_{0.97}Mo_{0.03}Al_{1.00}$
Key: a. cal/mol·degr

interplane distances which we obtained with the data of reference [5], one can conclude that the metastable phase observed is Ni_3Mo. Certain divergences in the interplane distances are caused by the anisotropy of the formations.

For studies of the behavior of the alloys after different thermal treatments, a temperature relationship of the heat capacity for the alloy with a content of 0.5% Mo was studied (Figure 2). It is apparent in Figure 2 that the curves C_p--T for alloys hardened at 1073 and 1523°K basically differ from curves for the alloys after hardening at 1173 and 1273°K. An analysis of the curves of peak /144 capacity make it possible to conclude that the metastable phase observed exists above 1173 and below 1523°K for an alloy with 0.5% Mo. These effects fixed when heating the sample after hardening from 1073 and 1523°K are caused by processes of ordering, thermal effects of ordering equal to 12.7 and 37.8 cal/mol, respectively.

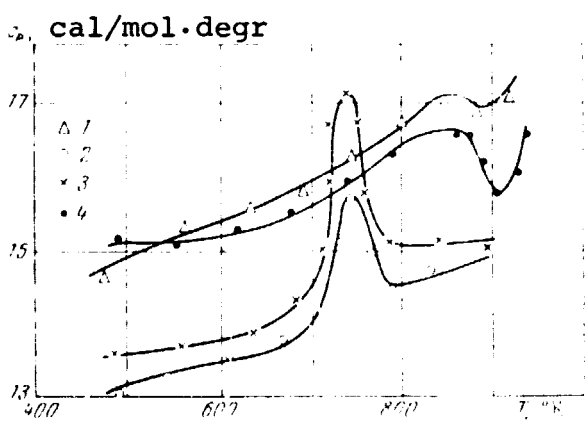

Figure 2. Heat capacity of the $Ni_{0.99}Mo_{0.01}Al_{1.00}$ alloy after hardening with temperatures of 1073 (1), 1173 (2), 1273 (3) and 1523°K (4).

Data on heat capacity are found in good agreement with the results of microscopic and X-ray phase analyses. For alloys hardened at 1523°K, the period of the lattice increases: for an alloy with 0.5% Mo the line of the new phase is absent and in alloys with 1 and 1.5% Mo, according to the data of X-ray phase analysis, the quantity of the phase is decreased. For an alloy with 0.5% Mo,

in this connection, an endothermal effect is not fixed. Consequently, the endothermal effect is due to formation in the hardened alloys of a metastable phase and it dissolution during heating. A comparison of data for the alloy with 0.5% Mo and for pure NiAl indicates that at 1073 and 1523°K the molybdenum decreases the degree of disordering of the crystal lattice of NiAl.

Conclusions

1. The temperature dependence of heat capacity of NiAl compounds was studied in relation to the size of additions of molybdenum and the thermal processing.

2. In a temperature interval $1073<T<1523$°K in the alloys a metastable phase Ni_3Mo was formed.

3. Molybdenum introduced into the alloy, at the expense of nickel prevents disordering of the NiAl lattice at a temperature of 1073 and 1523°K.

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